Guideline

Acute Arterial Ischaemic Stroke Management in Children

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Primary Document			
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Accountable Officer	Executive Director Clinical Services	**Effective date**	14/04/2025
Applicable to	Medical, Nursing and Radiology Staff working at Children's Health Queensland	**Review date**	07/03/2026

HUMAN RIGHTS

This governance document has been human rights compatibility assessed. No limitations were identified indicating reasonable confidence that, when adhered to, there are no implications arising under the *Human Rights Act 2019.*

PURPOSE

This guideline provides clinical practice recommendations to inform health professionals about assessment and management of children where there is high level clinical suspicion of Acute Arterial Ischaemic Stroke (AIS). Guidance is provided to assist in identification, investigation and treatment of patients that may be eligible for hyperacute reperfusion therapies including IV Alteplase (tPA) infusion and endovascular thrombectomy. Guidance is also provided regarding supportive medical management.

At QCH there are related documents outlining the diagnosis and management of children presenting with possible acute ischemic stroke:

- CHQ-PROC-00737 – Paediatric Code Stroke Activation
- CHQ-WI-00738 – Triage of Children with suspected Acute Arterial Ischaemic Stroke
- Clinical Pathway – Emergency Management of Suspected Paediatric Acute Arterial Ischaemic Stroke
- Consent Child/Young Person (under 18 years)

- PedNIHSS
- MRI Safety Questionnaire (Child)
- MRI Safety Questionnaire (Parent)

SCOPE

Specifically, this guideline refers to Acute Arterial Ischaemic Stroke (AIS) in children.

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GUIDELINE

INTRODUCTION

Paediatric Acute Arterial Ischaemic Stroke (AIS) has a mortality rate of 5-10%. More than half of the survivors have long term neurological impairment and 10-20% suffer recurrent strokes. Childhood stroke places significant demands on the healthcare system, families and the community.

Child specific diagnostic and management regimes are crucial. This is mandated by the national guideline due to the complexity in diagnosis and management of stroke in children given the higher frequency of stroke mimics, variability in age of presentation, diversity of causes (which differ from adult stroke) and of complex co-morbid conditions.

EPIDEMIOLOGY

In developed countries, the reported incidence of Acute Arterial Ischaemic Stroke (AIS) in children over one month of age ranges from 1.2 - 8 per 100 000 per year. These incidence rates equate to 58-390 strokes in children each year in Australia.

RISK FACTORS

Major risk factors for Acute Arterial Ischaemic Stroke in children include cardiac disease, arteriopathies (such as focal cerebral arteriopathy and cervicocephalic arterial dissection), head and neck trauma, sickle cell disease and haematological disorders. Approximately 50% of strokes occur when children have been previously well.

CHILDHOOD ARTERIAL ISCHAEMIC STROKE MIMICS

Various conditions can mimic Acute Arterial Ischaemic Stroke in children. The most common mimics include migraine, seizures with Todd's paresis, Bell's palsy and functional disorders. Other mimics include (but are not restricted to) cerebellitis, infection, acute disseminated encephalomyelitis (ADEM) and brain tumours. Clinical assessment and pathways to support time-critical decision making regarding urgent neuroimaging are essential for accurate and timely diagnosis.

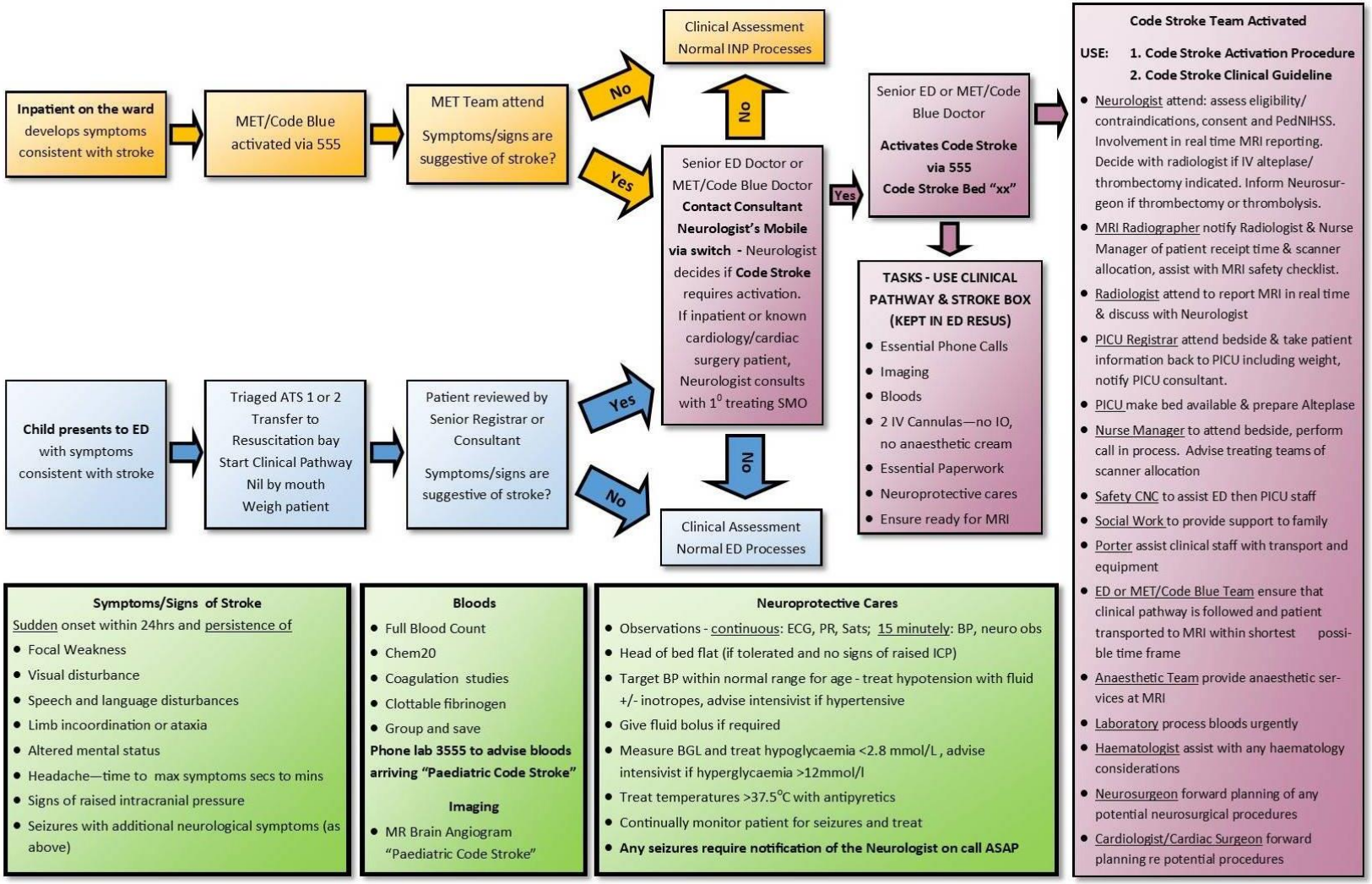
ALERT

Time is Brain

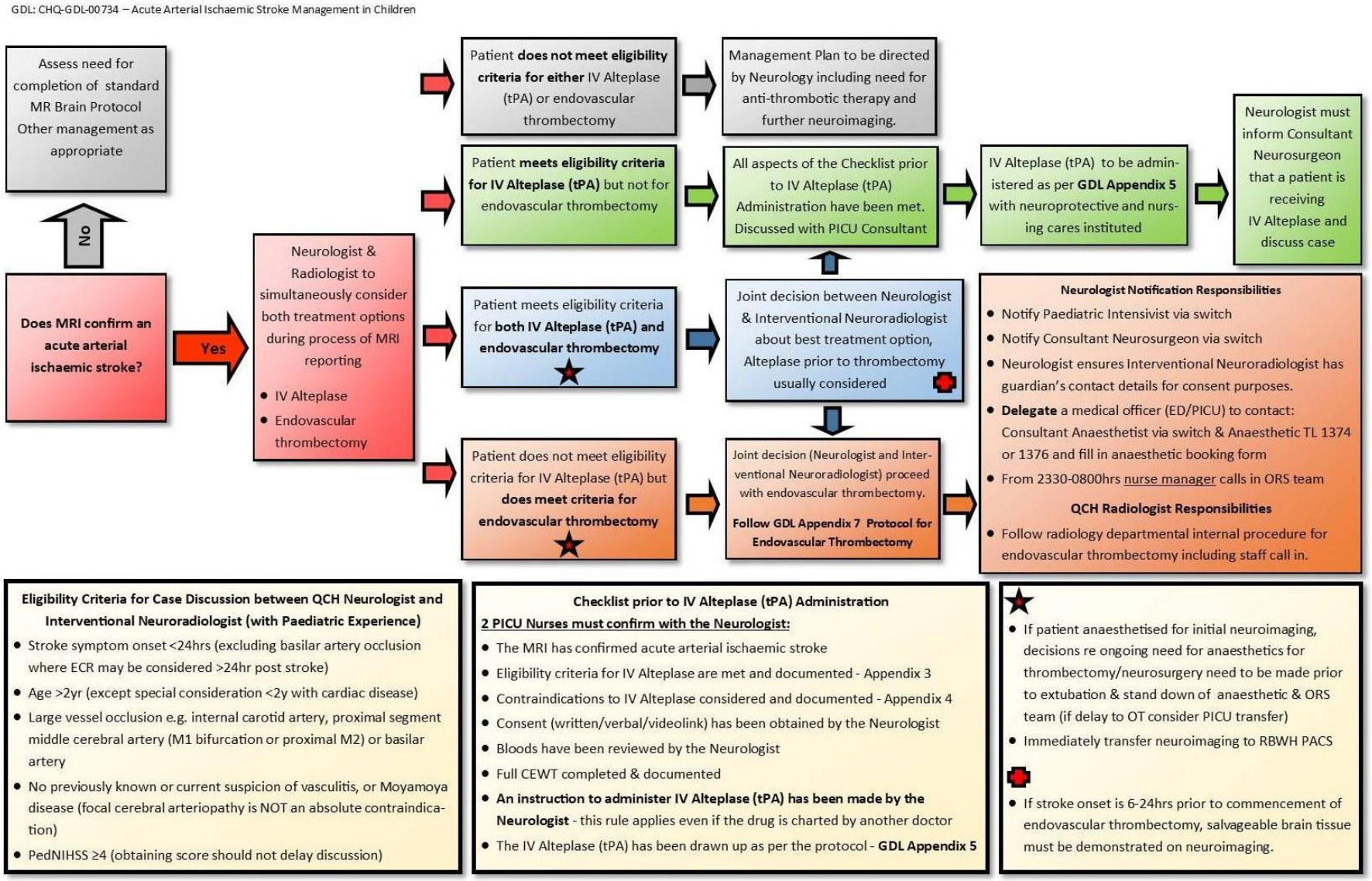
For early advice regarding the management of the child with suspected Acute Arterial Ischaemic Stroke and to discuss the potential need for retrieval, contact Retrieval Services Queensland (RSQ) on 1300 799 127.

The on-call QCH Neurology Consultant needs to be included early in the advice call.

Flowchart 1 Symptom Identification, Triage, Assessment, Activation of Stroke Code Procedure and Team



Flowchart 2: Decision Process after Neuroimaging Confirmation of Acute Arterial Ischaemic Stroke



STROKE IDENTIFICATION AND PROCESS OF CODE STROKE ACTIVATION FROM ED

ALERT

Children presenting with SUDDEN onset (within the last 24 hours and where there are ongoing symptoms and signs) of the following symptoms are at high risk of stroke and should undergo immediate neurological assessment and consideration of urgent neuroimaging.

- **Focal weakness**
- **Visual disturbances**
- **Speech and language disturbances**
- **Limb incoordination or ataxia**
- **Altered mental status**
- **Headache where time to maximal symptoms occurs over seconds to minutes**
- **Signs of raised intracranial pressure**
- **Seizures with additional neurological symptoms**

TRIAGE

See Appendix 1 - Triage of Children with Suspected Acute Arterial Ischaemic Stroke and CHQ-WI-00738 – Triage of Children with suspected Acute Arterial Ischaemic Stroke.

Children presenting to the Emergency Department with symptoms suggestive of possible Childhood Acute Arterial Ischaemic Stroke (AIS) should be triaged as a minimum Australian Triage Scale (ATS) 2 and initial resuscitative measures implemented if required.

CLINICAL PATHWAY

Children who are triaged as possible Acute AIS should be placed on the appropriate clinical pathway.

Clinical Pathway - Emergency Management of Suspected Paediatric Acute Arterial Ischaemic Stroke

- This document gives detailed instructions for the management of the patient with suspected/confirmed acute AIS.

ASSESSMENT AND DECISION TO ACTIVATE THE CODE STROKE

A Rapid Assessment is then performed by an ED Consultant (preferable) or Senior Registrar to establish if the presenting symptoms in conjunction with the history are suggestive of suspected acute AIS. If the symptoms and/or signs are suggestive then the on-call neurologist should be contacted on their mobile immediately via switch.

There is a growing body of evidence to show that implementation of a standardized immediate response protocol in paediatric emergency departments reduces the delay in diagnosis and improves access to available reperfusion therapies and management.

- The Neurologist will advise the Emergency/Critical Care Medical Staff to activate "Code Stroke" via 555.
- See CHQ-PROC-00737 – Paediatric Code Stroke Activation
  - This document gives detailed role descriptions for Code Stroke Team Members at QCH.

STROKE IDENTIFICATION AND PROCESS OF CODE STROKE ACTIVATION FROM AN INPATIENT WARD

ALERT

Children presenting with SUDDEN onset (within the last 24 hours and where there are ongoing symptoms and signs) of the following symptoms are at high risk of stroke and should undergo immediate neurological assessment and consideration of urgent neuroimaging.

See Appendix 1 for more detail.

- **Focal weakness**
- **Visual disturbances**
- **Speech and language disturbances**
- **Limb incoordination or ataxia**
- **Altered mental status**
- **Headache where time to maximal symptoms occurs over seconds to minutes**
- **Signs of raised intracranial pressure**
- **Seizures with additional neurological symptoms**

MET TEAM ACTIVATION

- See CHQ-PROC-62426 – Rapid Response System: Medical Emergency Team (MET) and Code Blue Activation and Response.
- If Nursing or Medical Staff are concerned that a child has any of the above symptoms suggestive of Acute AIS a MET or Code Blue via 555 should be activated. A Rapid Assessment is then performed by the team to establish if the presenting symptoms are suggestive of suspected acute AIS. If the symptoms and/or signs are suggestive then the on-call neurologist should be contacted on their mobile immediately via switch and the child should be placed on the appropriate clinical pathway. The admitting SMO should also be notified.

CLINICAL PATHWAY

- See Clinical Pathway - Emergency Management of Suspected Paediatric Acute Arterial Ischaemic Stroke
  - This document gives detailed instructions for the management of the patient with suspected/confirmed acute arterial ischaemic stroke.

ACTIVATION OF THE CODE STROKE

- The Neurologist will advise the Team/Critical Care Medical Staff to activate the "Code Stroke" via 555. Note for inpatients the decision to activate the code should occur in consultation with the primary treating SMO without delay. The Cardiologists and Cardiac Surgeons are required to be involved in all decisions regarding stroke in their patients.
- See CHQ-PROC-00737 – Paediatric Code Stroke Activation
  - This document gives detailed role descriptions for Code Stroke Team Members at QCH.

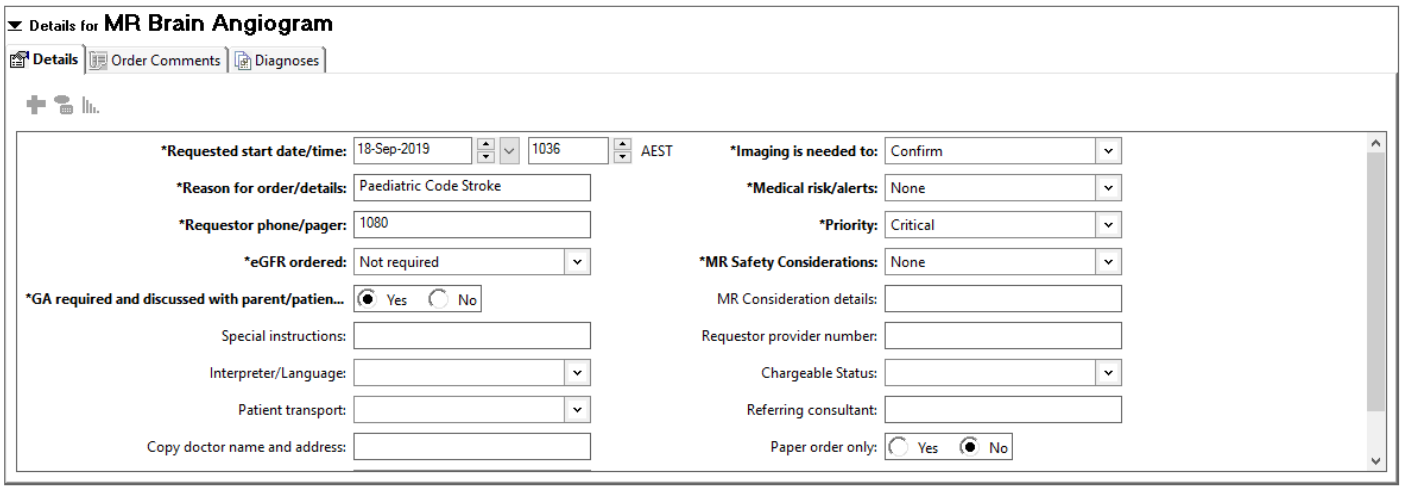
POST CODE STROKE ACTIVATION PROCEDURES

NEUROIMAGING

Neuroimaging is essential for the diagnosis of childhood stroke and to differentiate stroke from stroke mimics.

CT and MRI have equal sensitivity in detecting intraparenchymal blood. However, in children with Acute AIS, CT can often miss the early signs of infarction resulting in a delayed diagnosis and therefore, cannot definitively differentiate between stroke and mimics in children. MRI is the most sensitive modality for diagnosis of Acute AIS.

In rare instances (MRI contraindicated, not available for technical reasons) CT/CT-A can be considered by the Neurologist in consultation with the Radiologist and Interventional Neuroradiologist to exclude an intracranial haemorrhage and confirm large vessel occlusion. There are significant limitations associated with CT/CT-A in childhood stroke and the diagnosis may be missed.



See Appendix 2 - MRI Protocol for MR Brain Angiogram "Paediatric Code Stroke"

ALERT

Time is Brain - This is an Emergency

MRI Brain Angiogram "Paediatric Code Stroke"

MRI performed as rapidly as possible, less than one hour of presentation is highly desirable and every effort should be made to achieve this.

MRI is the diagnostic modality of choice. In children with suspected ischaemic arterial stroke where urgent MRI is not possible, CT imaging, including CT angiogram can be considered as an alternative. The CT/CTA can form the basis of discussion of endovascular thrombectomy if all other eligibility criteria are met.

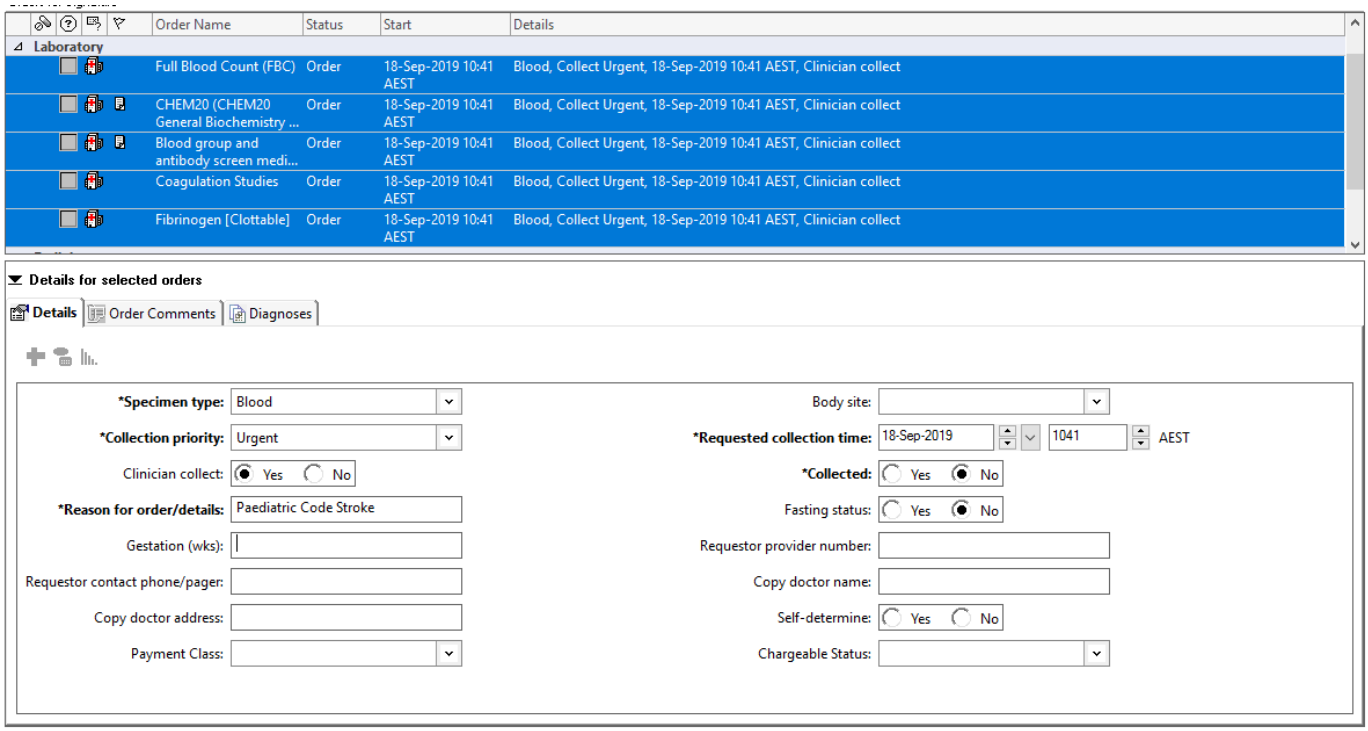
In children with suspected haemorrhagic stroke urgent MRI or CT should be performed. Neurosurgery should be urgently contacted.

IV ACCESS

2 Intravenous cannulas should be urgently placed - suggested 22G (blue). **No anaesthetic cream.**

Avoid IO unless this is a life-saving intervention. There is high risk of compartment syndrome with resultant potential threat to the limb in stroke patients where thrombolysis with IV Alteplase (tPA) is given after IO insertion.

LABORATORY INVESTIGATIONS



- At presentation all children with suspected acute ischaemic arterial stroke should have urgent bloods sent to the laboratory. "**Paediatric Code Stroke**" will be documented in the "reason for order/details" section. The person sending the bloods to the laboratory must **call extension 3555** and notify the scientist of the Code Stroke and the patient's name and UR. If there are any problems 3525 can be used as the alternative.
- **Once notification is received, the laboratory staff must ensure that the bloods are given immediate priority** as the administration of IV Alteplase (tPA) cannot occur until the results are available.
- The tests that need to be ordered include:
    1. Full blood count
    2. Chem20 (General Biochemistry Profile) – includes glucose, electrolytes, renal function and liver function tests
    3. Coagulation profile
    4. Clottable fibrinogen
    5. Group and save
- The Scientist must notify results **directly to the on call neurologist** via switch.

MRI COMPATIBLE MONITORING AND SAFETY QUESTIONNAIRE COMPLETION FOR MRI

- If the child requires ECG monitoring, he/she will not be able to enter the MRI scanner unless MRI compatible monitoring dots are applied. Radiology holds stock of these items and will place them on the patient at arrival in radiology.

- The MRI Safety Questionnaires are to be completed by the ED Staff (Medical). If the parent/guardian is going to enter the MRI, even to get the child settled, then they need an MRI Safety Questionnaire completed. These documents should be given to the parents as soon as possible to ensure that completion does not delay access to the scanner:
  - MRI Safety Questionnaire (Child)
  - MRI Safety Questionnaire (Parent)

STROKE SEVERITY SCORE

The paediatric modification of the National Institutes of Health Stroke Scale (PedNIHSS) is appropriate for use in children between 2-18 years of age. This should be performed by the treating Neurologist or other senior medical staff to assist with decision making if time allows. **This assessment should not delay access to the MRI scanner.**

NEUROPROTECTIVE CARES

The medical stabilisation of modifiable factors in children with suspected or confirmed stroke aims to minimise brain injury, prevent stroke extension and optimise neurological outcome.

Blood pressure (BP), glucose, temperature, oxygen levels, hydration status and seizures need careful monitoring.

BLOOD PRESSURE

Currently there is not sufficient evidence to emphatically guide treatment of BP. In children with suspected or confirmed acute arterial ischaemic stroke, the reduction of significantly and persistently elevated blood pressure can be considered in the acute setting. Blood pressure target should be < 95th centile for age and length (Appendix 8: Blood Pressure Measurements for Infants and Children). Blood pressure should not be lowered by more than 30% of the targeted drop in the first 8 hours unless there is a medical or surgical emergency. If the decision is made to treat hypertension, there should be close and ongoing monitoring of blood pressure with avoidance of long acting agents and hypotension as maintenance of adequate cerebral perfusion pressure is required.

GLUCOSE

In children with suspected or confirmed arterial ischaemic stroke, targeting a normal blood glucose can be considered. If the decision is made to treat, an intensive approach to the maintenance of tight glycaemic control is not recommended. If a decision is made to target a blood sugar of < 12 mmol/L this should be closely supervised by the treating intensivist and can only occur in a critical care setting.

TEMPERATURE

There are good biological reasons and supporting evidence in other paediatric cohorts to suggest fever may adversely affect neurological outcome after injury. Hyperthermia leads to a hypermetabolic state where the demand for oxygen and glucose is increased. In the setting of ischaemic stroke, where the substrate delivery is impaired, fever may lead to further injury. In children with traumatic brain injury therapeutic hypothermia (target temperatures <34 degrees) has not been shown to improve neurological outcomes above targeted temperature management (target temperatures 34-37 degrees). At this time therapeutic hypothermia in children with stroke should not be administered outside of clinical trials.

In all children with suspected or confirmed stroke, active steps should be made to avoid hyperthermia (>37 degrees) via administration of paracetamol. Other measures to control hyperthermia need to be under the guidance of an intensivist. Targeted temperature management should be considered if signs of raised ICP are present.

OXYGEN SUPPLEMENTATION

In all children with suspected or confirmed stroke, oxygen supplementation is not recommended unless monitoring demonstrates hypoxia ≤93%. Supplemental oxygen is considered reasonable in hypoxic children.

HYDRATION

Optimisation of hydration status is reasonable however the child should remain nil by mouth until swallowing status is assessed.

SEIZURES

Seizures are a common clinical presentation of childhood stroke. Seizures are likely to be harmful on short and long-term neurological outcomes. Prolonged or recurrent seizures may herald stroke extension or recurrence, malignant middle cerebral artery infarction or haemorrhagic transformation and should therefore prompt urgent neurological and neurosurgical review.

In all children with suspected or confirmed stroke the neurologist should be notified of any seizures. Intravenous levetiracetam, phenytoin or other anticonvulsant treatment will be considered. For status epilepticus ALPS and/or hospital guidelines should be followed. Standard EEG or continuous EEG monitoring may be required.

REPERFUSION THERAPIES

Treatment with intravenous IV Alteplase (tPA) and endovascular thrombectomy have been proven to be effective in multiple large randomised controlled trials in adults and have revolutionised the management of acute AIS in adults, reducing the severity of disability and mortality rates. There are no such trials in children. Due to the absence of randomised trial evidence for benefit, thrombolytic agents are not approved by the Therapeutic Goods Administration for use in Australian children with Acute Arterial Ischaemic Stroke.

Despite this, there are a growing number of international publications reporting use of these interventions. The Australian National Guideline "Diagnosis and Acute Management of Childhood Stroke"[1] and the AHA guideline "Management of Stroke in Neonates and Children"[3] provide guidance for thrombolysis with IV Alteplase (tPA) and endovascular thrombectomy in children. The objective of reperfusion therapies in childhood acute arterial ischaemic stroke is prompt recanalization of occluded vessels and the restoration of cerebral blood flow to increase brain tissue survival primarily in the penumbra.

ALERT

Decision to treat must be made in consultation with the Paediatric Neurologist

Intravenous Alteplase (tPA) should ideally be administered at Queensland Children's Hospital. It may be considered at other sites but only in consultation with and at the direction of the QCH Paediatric Neurologist.

Endovascular thrombectomy. The decision to perform endovascular thrombectomy is to be made in consultation with and at the direction of the QCH Paediatric Neurologist.

Endovascular thrombectomy should only be performed by an experienced Interventional Neuroradiologist with recognised training in the procedure (Conjoint Committee for Recognition of training in neuro-interventional radiology CCINR.org.au) and with sufficient experience in paediatrics. For procedures performed at Queensland Children's Hospital, the interventional neuroradiologist must be credentialed at QCH to perform this procedure. Emergency credentialing can be undertaken in some circumstances.

THROMBOLYSIS WITH IV ALTEPLASE (TPA)

Intravenous Alteplase (tPA) is used in patients with stroke to break down blood clots that are causing cerebral artery occlusion. It has proven effectiveness in adults with stroke when given <4.5 hours following stroke onset. The same time window for treatment is used in paediatric patients despite a lack of evidence demonstrating direct translatability. The eligibility and exclusion criteria and contraindications are also based on adult evidence and guidelines. An age of 2yrs or greater is currently included as a criteria for thrombolysis with IV Alteplase. See the following appendices for other eligibility criteria along with exclusion criteria, contraindications and dosing and administration information:

- Appendix 3 – Eligibility Criteria for Thrombolysis with IV Alteplase
- Appendix 4 - Contraindications for Thrombolysis with IV Alteplase
- Appendix 5 - Protocol for Thrombolysis with IV Alteplase for Paediatric Acute AIS
- Appendix 6a - Gaining Consent for IV Alteplase (tPA) for Paediatric Acute AIS
- Appendix 6b - Information for Parents and Guardians - IV Alteplase (tPA) use in Paediatric Acute AIS

The Consultant Neurologist should notify the Neurosurgical Consultant of all cases where the child is to undergo thrombolysis with IV Alteplase.

ENDOVASCULAR THROMBECTOMY

Queensland Children's Hospital does not have an interventional neuroradiologist on site. For acute AIS cases that are being considered for endovascular thrombectomy, the Neurologist and Radiologist will immediately discuss the patient with the interventional neuroradiologist on-call at the Royal Brisbane and Women's Hospital. If the on-call interventional neuroradiologist is not credentialed to provide services at QCH, or is unavailable, they will liaise with other Brisbane interventional neuroradiologists if available to discuss the patient directly with the referring paediatric neurologist. Emergency credentialing can be undertaken in some circumstances via the EDMS.

Decisions regarding endovascular thrombectomy will be made on a case-by-case basis. Further neuroimaging may be required to assist in decision-making. The time window for performing endovascular thrombectomy is ideally <6 hours post stroke symptom onset however later treatment up to 24hrs may be considered in select cases. IV Alteplase (tPA) administration is not a contraindication to endovascular thrombectomy. All patients undergoing endovascular thrombectomy will require a general anaesthetic and intensive care unit admission following the procedure.

The Consultant Neurologist should notify the Neurosurgical Consultant of all cases where the child is to undergo endovascular thrombectomy.

There is no definite lower age limit in children however, factors such as the relationship of artery to device size limits the use of endovascular thrombectomy in infants and very young children.

See Appendix 7 – Protocol for endovascular thrombectomy.

ALERT

Administration of IV Alteplase (tPA) or performance of endovascular thrombectomy

The absence of high-quality evidence means that benefit over harm of IV Alteplase (tPA) use or endovascular thrombectomy in paediatric acute AIS cannot be accurately assessed. Where administration of IV Alteplase (tPA) or endovascular thrombectomy is being considered for children with acute AIS an experienced team of paediatric neurologists, paediatric radiologists, paediatric haematologists, and if required interventional neuroradiologists and paediatric critical care specialists within a Tertiary Paediatric Hospital should be involved. Professionals should take a cautious approach, appreciating that the safety and efficacy in children remains to be fully elucidated.

ANTITHROMBOTIC THERAPY

ANTICOAGULATION AND ANTIPLATELET THERAPY

In children there are currently no randomised controlled trials published on the efficacy of anticoagulation or antiplatelet therapy in children with acute AIS. Despite the absence of controlled trials, there is a body of evidence supporting the efficacy and safety of using anticoagulation and antiplatelet therapy in children with stroke and multiple international guidelines provide recommendations for antithrombotic therapy. The goal for antithrombotic therapy is to reduce the risk of stroke extension or recurrence.

This guideline does not include instructions for antithrombotic therapy except when applicable to reperfusion therapies IV Alteplase (tPA) and endovascular thrombectomy. Reference should be made to The Australian national guidelines for the "Diagnosis and Acute Management of Childhood Stroke".

STROKE COMPLICATIONS (WITH OR WITHOUT TREATMENT):

Neurological deterioration, clinical signs of raised intracranial pressure or abnormalities in vital signs in a patient with acute arterial ischaemic stroke may be indicative of a complication such as stroke extension, recurrent stroke, haemorrhagic stroke conversion or malignant cerebral oedema/malignant middle cerebral artery infarction. This requires immediate medical and surgical review.

RAISED INTRACRANIAL PRESSURE AND DECOMPRESSIVE CRANIECTOMY FOR ACUTE ARTERIAL ISCHAEMIC STROKE

Raised Intracranial Pressure (ICP) due to malignant cerebral oedema surrounding the stroke can occur in paediatric patients with Acute Arterial Ischaemic Stroke and is a major contributor to morbidity and mortality in paediatric stroke. Timely intervention (decompressive hemicraniectomy and supportive medical management) may be lifesaving and may reduce morbidity. The two most relevant clinical scenarios are extensive middle cerebral artery infarction (so called malignant middle cerebral artery infarction [MMCAI]) and infratentorial stroke with oedema, brainstem compression and obstructive hydrocephalus.

Early recognition is essential to outcome thus , close clinical observation in the first few hours to days after acute AIS is warranted. Malignant oedema usually develops within the first 72 hours following an acute AIS

but can rarely occur later. Important indicators include deteriorating level of consciousness, unilateral pupillary dilatation, abnormal eye movements, worsening of existing neurological deficit, development of other focal neurological deficits and a change in vital signs (developing hypertension or bradycardia). Emergent notification and assessment by the intensivist, neurosurgeon and neurologist is required with any deterioration in neurological status.

Initial supportive care of raised intracranial pressure includes 30 degrees elevation of the head of the bed, maintenance of normal oxygenation, adequate hydration/euvolaemia, nil oral intake, temperature control (prevention of hyperthermia by actively target temperature of ≤ 37.5 degrees), prevention of hypotension, maintaining serum sodium levels at ~ 145 mmol/L and control of seizures. Medical management may also include administration of hypertonic saline and/or mannitol and sedation. Intubation and mechanical ventilation may be required. The child should be managed in PICU.

The Guideline CHQ-GDL-80114 Management of Severe Traumatic Brain Injury in Children can be used as an additional guide to assist with medical management principles associated with raised intracranial pressure.

Provision of supportive medical care should not delay assessment for decompressive hemicraniectomy which can prevent death and secondary brain injury especially to the unaffected hemisphere and improve outcome.

CHILDREN PRESENTING TO HOSPITALS OTHER THAN QUEENSLAND CHILDREN'S HOSPITAL

If a child presents to another hospital in Queensland with symptoms and signs suggestive of acute arterial ischaemic stroke (AIS) Retrieval Services Queensland (RSQ) should be immediately contacted. The Paediatric Medical Coordinator (PMC) and the Paediatric Neurologist will be conferenced in to enable simultaneous time-critical advice and retrieval processes to be commenced.

Modification of the diagnostic pathway may be required if MR imaging is not available urgently. Decisions regarding acute treatment and retrieval of a child with stroke will be made on a case by case basis taking into account site and individual factors.

ALERT

Time is Brain

For early advice regarding management of a child with suspected Acute Arterial Ischaemic Stroke and to discuss the potential need for retrieval, contact Retrieval Services Queensland (RSQ) on 1300 799 127.

SUPPORTING DOCUMENTS

POLICY, STANDARD, PROCEDURES, GUIDELINES, PROTOCOLS, FORMS AND TEMPLATES

- CHQ-WI-00738 – Triage of Children with suspected Acute Arterial Ischaemic Stroke
- Clinical Pathway – Emergency Management of Suspected Paediatric Acute Arterial Ischaemic Stroke
- CHQ-PROC-62426 – Rapid Response System: Medical Emergency Team (MET) and Code Blue Activation and Response
- CHQ-PROC-00737 – Paediatric Code Stroke Activation
- Australian National Clinical Guideline The Diagnosis and Management of Childhood Stroke – Clinical Guideline 2017

- CHQ-GDL-80114 – Management of Severe Traumatic Brain Injury in Children
- CHQ-GDL-60014 – Status epilepticus – Emergency management in children

CONSULTATION

Key stakeholders who reviewed this version:

- Staff Specialist, Paediatric Neurology, Queensland Children's Hospital
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- Staff Specialist, Paediatric Emergency Medicine, Queensland Children's Hospital
- Nurse Unit Manager, Paediatric Emergency Medicine, Queensland Children's Hospital
- Director, Paediatric Intensive Care, Queensland Children's Hospital
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- Fellow, Paediatric Intensive Care, Queensland Children's Hospital
- Nurse Unit Manager, Paediatric Intensive Care, Queensland Children's Hospital
- Director, Paediatric Radiology, Queensland Children's Hospital
- Staff Specialist, Paediatric Radiology, Queensland Children's Hospital
- Neuro-interventionalist, Radiology, Royal Brisbane and Women's Hospital
- Staff Specialist, Paediatric Haematology, Queensland Children's Hospital
- Director, Paediatric Anaesthesia, Queensland Children's Hospital
- Director Neurosurgery, Queensland Children's Hospital
- Divisional Director Medicine, Queensland Children's Hospital
- Director, General Paediatrics, Queensland Children's Hospital
- Director Cardiology, Queensland Children's Hospital
- Director of Cardiac Surgery, Queensland Children's Hospital
- Director CATCH, Queensland Children's Hospital
- Medical Director, Retrieval Services Queensland
- Director, Retrieval Services, Queensland Children's Hospital
- CNC, Retrieval Services, Queensland Children's Hospital
- Medical Director, Queensland Ambulance Service
- Pharmacist, Safety and Quality, Queensland Children's Hospital
- Pharmacist Lead, Critical Care, Queensland Children's Hospital
- Operational Manager, Pathology Queensland
- Haematology Supervisor, Pathology Queensland
- Director, Patient Safety and Quality
- Director, Patient Flow
- Senior Lawyer, Queensland Children's Hospital

DEFINITIONS

Term	Definition
Acute Arterial Ischaemic Stroke (AIS)	A neurological syndrome defined by the presence of a sudden neurological deficit associated with a concordant area of focal infarction seen on neuroimaging. The area of infarction must conform to a defined arterial territory such as the middle, anterior or posterior cerebral artery territory.
Malignant Middle Cerebral Artery Infarction Syndrome	Rapid neurological deterioration due to the effects of space occupying cerebral oedema after MCA territory stroke. Progressive oedema and mass effect lead to transtentorial, subfalcine or uncal herniation.

REFERENCES

No.	Reference
1	Australian Childhood Stroke Advisory Committee, *The Diagnosis and Acute Management of Childhood Stroke Clinical Guideline 2017*, https://www.mcri.edu.au/sites/default/files/media/stroke_guidelines.pdf
2	Australian Childhood Stroke Advisory Committee, *The Diagnosis and Acute Management of Childhood Stroke – Technical Document – 2017,*
3	Management of Stroke in Neonates and Children A Scientific Statement From the American Heart Association/American Stroke Association
4	PhenXToolkit Protocol – Pediatric NIH Stroke Scale (PedNIHSS) https://www.phenxtoolkit.org/protocols/view/820802#Source
5	QH Guide to Informed Decision-Making in Health Care (2nd ed).
6	Blood and Blood Product Consent

GUIDELINE REVISION AND APPROVAL HISTORY

Version No.	Modified by	Amendments authorised by	Approved by	Comments
1.0 26/09/2019	Paediatric Stroke Working Group and Director, Emergency	Divisional Director, Critical Care	Executive Director Clinical Services (QCH)	
2.0 17/02/2023	Director, Paediatric Emergency Medicine	Divisional Director, Critical Care	Executive Director Medical Services	
2.1 16/04/2024	Governance Officer (Documents)		Executive Director Clinical Services	
2.2 07/04/2025	Director, Emergency Department	Divisional Director, Critical Care	Executive Director Clinical Services	Review extension

Key words	stroke, paediatric stroke, Alteplase, tPA, rtPA, clot retrieval, endovascular thrombectomy, thrombectomy, hyperacute therapies, reperfusion therapies, reperfusion, emergency, PICU, neurology, neurosurgery, radiology, cardiac surgery, cardiology, anaesthetics, anaesthesia, interventional radiology, interventional neuroradiology, 00734

Accreditation references	NSQHS Standards (1-8):
	• 1 Clinical Governance
	  ○ Actions 1.6, 1.27 and 1.7
	• 5 Comprehensive Care
	  ○ Actions 5.2, 5.7 and 5.13
	• 6 Communication for Safety
	  ○ Actions 6.5, 6.6 and 6.7
	• 8 Recognising and Responding to Acute Deterioration
	  ○ Actions 8.1, 8.4, 8.5, 8.6, 8.9 and 8.10
	ACHS Clinical Care Standard for Acute Stroke
	ISO 9001:2015 Quality Management System (4-10)

APPENDIX 1: TRIAGE OF CHILDREN WITH SUSPECTED ACUTE ARTERIAL ISCHAEMIC STROKE

The below information is referenced from CHQ-WI-00738 – Triage of Children with suspected Acute Arterial Ischaemic Stroke

Patients presenting to the Emergency Department at Queensland Children's Hospital (QCH) with symptoms/signs of any of the following within the last 24 hours need urgent and careful assessment for acute arterial ischaemic stroke and will be triaged as a **minimum ATS Category 2.**

Sudden onset within the last 24 hours where there are ongoing symptoms/signs of:

a) Focal weakness
   - limb (or part of limb) weakness – not thought to be obviously secondary to pain or trauma
   - facial droop

b) Visual or speech/language disturbances
   - double vision – not thought to be obviously due to trauma or infection
   - unequal pupils – new onset
   - loss of vision or change to normal vision – not thought to be obviously secondary to pain or infection
   - slurred speech or incomprehensible speech or inability to speak

c) Limb incoordination or ataxia
   - unsteady gait or increased frequent falling – not thought to be obviously secondary to pain or trauma

d) Altered mental status (use AVPU scoring)

e) Headache where the time to maximal symptoms occurs over seconds to minutes

f) Signs of raised intracranial pressure
   - Consider this if the child has headache that is associated with nausea/vomiting and/or confusion and/or bradycardia

g) Seizures with additional neurological symptoms (any symptoms from above list a-f)

APPENDIX 1: MRI PROTOCOL FOR MR BRAIN ANGIOGRAM "PAEDIATRIC CODE STROKE"

Sequences to be performed for investigation of Paediatric Acute Arterial Ischaemic Stroke should include:

Brain

1. Axial DWI
2. Axial T1WI
3. Axial T2WI (plus FLAIR if age >1)
4. Axial SWI (3-D SWI)
5. 3D TOF MRA (brain only)

The role of MRI perfusion sequences may be considered in future revisions of this guideline.

The default is: At all times (in and out of hours) the radiologist will attend in person to report the images in real time with the neurologist so that decision making regarding reperfusion therapies can be made. If the radiologist is in transit this should not delay the commencement of the MRI scanning.

If the radiologist and neurologist determine that further information is required for possible endovascular thrombectomy, the following sequences will be considered.

Neck

1. 3D TOF MRA (neck)

MRA neck should not delay administration of IV Alteplase (tPA).

APPENDIX 2: ELIGIBILITY CRITERIA FOR THROMBOLYSIS WITH IV ALTEPLASE

For patients with potentially disabling ischaemic stroke within 4.5 hours of onset who meet specific eligibility criteria, intravenous thrombolysis with IV Alteplase (tPA) should be administered as early as possible after stroke onset.

Eligibility Criteria for Thrombolysis with IV Alteplase (tPA)
Age >2yrs
Stroke radiologically confirmed by • MRI showing acute stroke on diffusion imaging plus MRA showing partial or complete arterial occlusion of the corresponding intracranial artery OR • CT and CT angiogram confirmation showing a normal brain parenchyma or minimal early ischemic change plus partial or complete arterial occlusion of the corresponding intracranial artery **AND** no evidence of any intracranial haemorrhage
Persistent disabling neurological deficit (PedNIHSS ≥ 4 at the time of intervention)
Time from stroke onset <4.5hrs

NOTE: Children with seizure at onset may be included as long as they fulfil the criteria above

APPENDIX 3: CONTRAINDICATIONS FOR THROMBOLYSIS WITH IV ALTEPLASE

Contraindications for Thrombolysis with IV Alteplase – page 1 of 2 pages
SAFETY RELATED EXCLUSIONS
Unknown time of symptom onset
Pregnancy
Clinical presentation suggestive of subarachnoid haemorrhage, even if head CT or head MRI scan is negative for blood
History of prior intracranial haemorrhage
Known cerebral arterial venous malformation, aneurysm or neoplasm
Unmanageable glucose <2.8 mmol/l or >22 mmol/l)
Patients with an underlying significant and unmanageable bleeding disorder as determined by the neurologist and haematologist. Patients with a mild platelet dysfunction, mild von Willebrand Disease or other mild bleeding disorders are not excluded.
Actual or potential bleeding diathesis – **seek Haematology advice for management**: Platelets <100 x10^9/L, PT >15 sec, INR >1.4, elevated APTT > upper limits of the normal range, clottable fibrinogen < 1.6 g/L), hepatic impairment.
Clinical presentation is consistent with acute myocardial infarction (MI) or post-MI pericarditis that requires evaluation by cardiology prior to treatment.
Stroke, major head trauma or intracranial surgery within the past 3 months
Major surgery or parenchymal biopsy within 10 days
Gastrointestinal or urinary bleeding within 21 days
Arterial puncture at non-compressible site or lumbar puncture within 7 days. Patients with cardiac catheterisation via a compressible artery are not excluded.
Patients with malignancy or within one month of completion of treatment for cancer
Unmanageable persistent SBP >15% above the 95th percentile for age while sitting or supine – **see other considerations for further explanation of this contraindication**
STROKE RELATED EXCLUSIONS
PedNIHSS <4 or >24 at start of IV Alteplase (tPA) infusion (PedNIHSS >24 indicates a very large territory stroke regardless of the infarct volume seen on neuroimaging)
Stroke suspected to be due to subacute bacterial endocarditis, MoyaMoya, sickle cell disease, meningitis, bone marrow, air or fat embolism.
Previously diagnosed primary angiitis of the central nervous system or secondary CNS vasculitis that is causative for the current stroke as determined by the stroke neurologist. Focal cerebral arteriopathy of childhood is not a contraindication.

Contraindications for Thrombolysis with IV Alteplase – page 2 of 2 pages

NEUROIMAGING RELATED EXCLUSIONS

Intracranial haemorrhage (HI-1, HI-2, PH-1 or PH-2) on MRI or CT

Intracranial dissection (defined as at or distal to the ophthalmic artery)

Large infarct volume, defined as 1/3 or more of the complete MCA territory diagnosed by MRI, due to increased risk of intracranial haemorrhage

DRUG RELATED EXCLUSIONS

Previous allergy or adverse reaction to IV Alteplase (tPA)

Patient on anticoagulation or antiplatelet therapy

- VKA/warfarin if INR > 1.4 and not correctable with vitamin K. Advice from haematologist mandatory.
- LMWH received within 24h
- DOACs (direct oral anticoagulants) if received within 24h
- Unfractionated Heparin received within 4 hours unless APTT is within the normal range or anti-Xa <0.01
- Antiplatelet agents received within 5 days (note aspirin is the only member of this group that is NOT a contraindication)

OTHER CONSIDERATIONS

Parental non-consent to blood transfusion should be considered in the decision to undertake thrombolysis with IV Alteplase.

It is noted that whilst guardian refusal to provide consent for blood transfusion is not an absolute contraindication, it is important to discuss the possible requirement for transfusion associated with the administration of IV Alteplase (tPA). It is also important to discuss the possible need to over-ride non-consent to blood products in the event of a situation which would risk the child's life or result in serious and permanent injury.[4]

Blood pressure: For teenagers and children of adult weight and height ranges reference can also be made to the (Australian) Clinical Guidelines for Stroke Management (2017) which lists the following as a relative contraindication (careful consideration of risk and benefit required):

"Severe uncontrolled high blood pressure: The standard recommendation based on expert consensus is to lower elevated blood pressure to < 185/110 mmHg prior to thrombolysis with IV Alteplase and maintain this level. If blood pressure cannot be lowered, then thrombolysis with IV Alteplase should not be commenced".

APPENDIX 4: PROTOCOL FOR GIVING IV ALTEPLASE (TPA) FOR PAEDIATRIC ACUTE ARTERIAL ISCHAEMIC STROKE

- The Code Stroke Activation Procedure should occur: CHQ-PROC-00737 – Paediatric Acute Arterial Ischaemic Code Stroke Activation
- The Patient should be placed on The Clinical Pathway – Emergency Management of Suspected Paediatric Acute Arterial Ischaemic Stroke
- This Guideline should be accessed for the below appendices:
  - Appendix 3: Eligibility Criteria for Thrombolysis with IV Alteplase
  - Appendix 4: Contraindications for Thrombolysis with IV Alteplase (2 pages)
  - Appendix 6a: Gaining Consent for IV Alteplase (tPA) for Paediatric Acute AIS
  - Appendix 6b: Information for Parents and Guardians - IV Alteplase (tPA) use in Paediatric Acute AIS

1. **Eligibility**: Document that the patient is eligible for Thrombolysis with IV Alteplase (Appendix 3)
2. **Contraindications**: Document that there are no contraindications to Thrombolysis with IV Alteplase (Appendix 4)
3. **Consent:** The treating neurologist is responsible for the verbal discussion of consent. If the neurologist is off site or the patient is in a hospital other than Queensland Children's Hospital, a phone or video-link consent can be performed with appropriate documentation in the ieMR. It is highly desirable that delayed written consent be performed in these instances wherever possible. (Appendix 6a and Appendix 6b)
4. **Weight:** Document accurate (not estimated) weight in either ieMR or metavision.
5. **Allergies:** Document allergies in either ieMR or metavision.
6. **IV Access:** Minimum 2x 22G IV cannulas, do not use intraosseous access. Note unsuccessful IV cannula attempts will bleed during an Intravenous IV Alteplase (tPA) infusion, use senior cannulator.
7. **Sedation +/- Intubation:** It is recommended that IV Alteplase is administered to awake patients who can have repeated neurological examinations. Both sedation alone and intubation with sedation severely limit clinical neurological assessment and are not recommended. If these procedures are considered life saving and if (in an exceptional circumstance) a decision is made to administer IV Alteplase to a sedated +/- intubated patient, then intubation should be performed prior to starting the IV Alteplase (tPA) infusion. There is risk of significant internal bleeding associated with mucosal trauma during the IV Alteplase (tPA) infusion and for 24hrs afterwards. Thus, it should be placed by an experienced clinician with attention to minimising trauma of the mucosal surfaces and other structures. IV Alteplase is a time-critical intervention, intubation should not delay commencement of the infusion.
8. **Procedures:**
   - **IV Alteplase (tPA) administration should not be delayed for catheterisation, NGT insertion or other procedures.**
   - Do not catheterise within 90 minutes of completion of the IV Alteplase (tPA) infusion. Catheterisation should be delayed, if safe, from the bladder point of view for as long as possible after completion of the infusion. Bladder ultrasound may be helpful in decision making. IF IDC is required, it should be placed by an experienced clinician. Use a small gauge.

- No punctures of arteries or large veins within 24hrs after starting IV Alteplase (tPA), unless benefit outweighs the risk. Always choose the most experienced operator and a compressible site.
- Leave IV cannula in-situ for blood collection. If emergency venepuncture is required, apply direct pressure to the site for 20 minutes.
- Avoid NGT insertion until 8 hrs post IV Alteplase (tPA) infusion.

9. **Laboratory Results:** Neurologist must review bloods and document results – Group and Save, FBC, Chem20, Coagulation Profile, Clottable fibrinogen and General Biochemistry Profile– includes glucose, electrolytes, renal function and liver function tests.

ALERT

Laboratory results indicative of a bleeding diathesis

Contact Haematology Consultant On-Call if there is an actual or potential bleeding diathesis:

- **platelets <100 x10^9/L**
- **PT >15 sec (INR >1.4)**
- **elevated APTT > upper limits of the normal range**
- **clottable fibrinogen < 1.6 g/L**
- **hepatic impairment**

Cryoprecipitate can be administered if the clottable fibrinogen is <1.6g/L
Patients with hepatic impairment may require modified doses due to an increased risk of bleeding.

10. **Neurosurgeon Contact:** the Neurologist is responsible for advising the Consultant Neurosurgeon that a child is receiving IV Alteplase for acute ischaemic stroke.

Storage

A 50 mg vial of Alteplase is always stored in PICU (Riverside Drug room), 10 mg vials are stored in the PICU (Hillside drug room). PICU registrar responsibility is to confirm that the appropriate dose of Alteplase is available once Code Stroke is activated. If the Alteplase is not available in PICU the on-call pharmacist can be contacted via switch as well as the safety CNC who can access the main pharmacy on level 2 and obtain the appropriate dose.

Prescribing

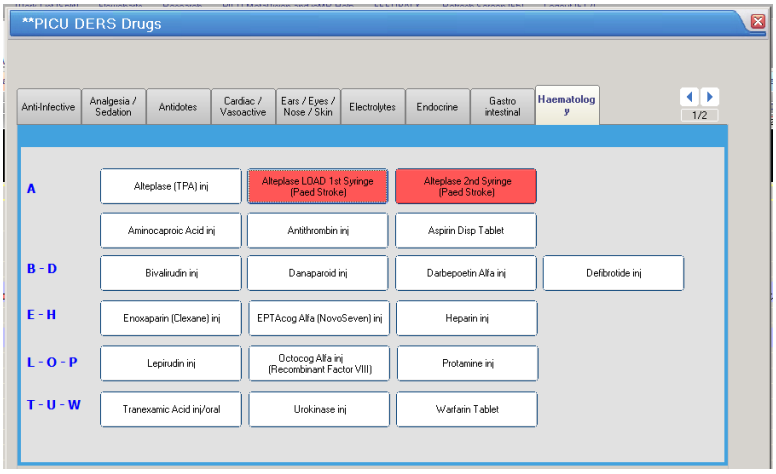
The Medical Officer (ICU Registrar or Consultant) will prescribe IV Alteplase (tPA) using the electronic medical record (ieMR) or Metavision. This will include:

- date and time of the order
- concentration of IV Alteplase (tPA)
- dose calculation in mg/kg
- rate of infusion in mL/hour and corresponding rate in mg/hour

Total Dose 0.9mg/kg (maximum 90mg) – prepare 2 syringes:

- **Syringe 1** - 0.09mg/kg (10% of total dose) – given as a push over 1 minute THEN
- **Syringe 2** - 0.81mg/kg (90% of total dose) (maximum of 81mg) infused over 59 minutes

Metavision Prescribing



Step 1: Select Medication Plan

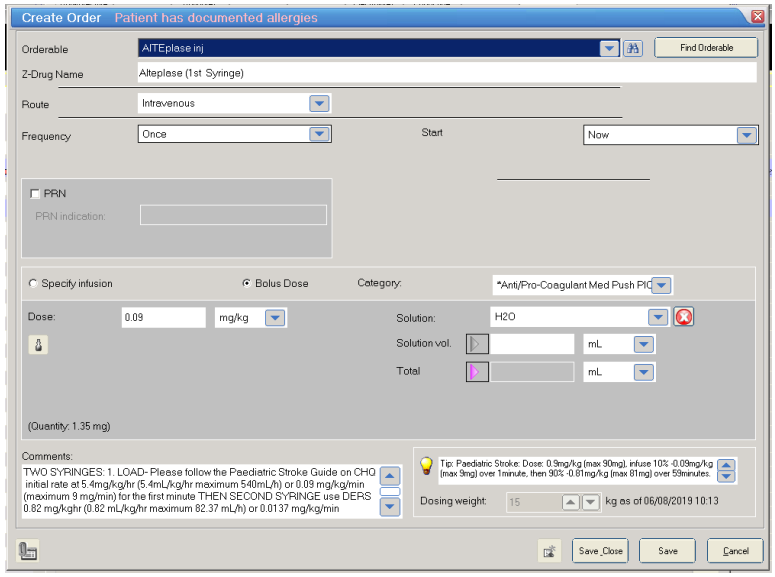
Step 2: Select the Haematology tab

Step 3: In the Haematology tab select

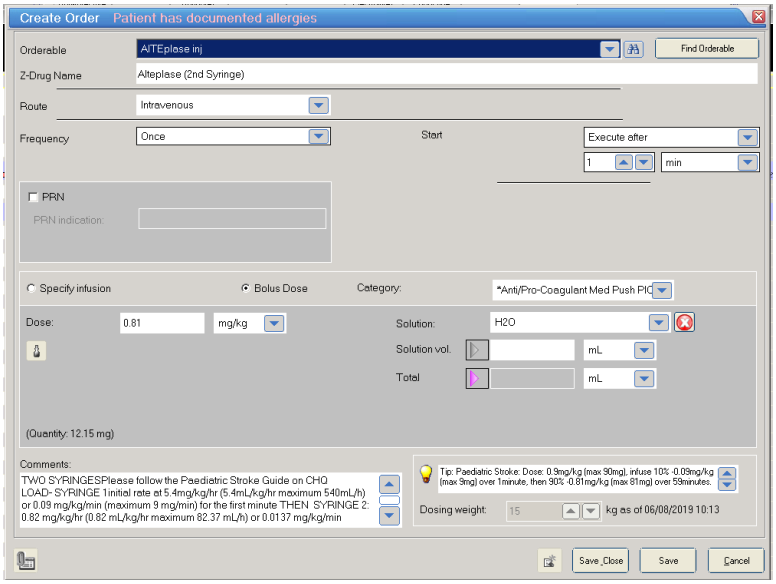
- *Alteplase LOAD 1st Syringe (Paed Stroke)*

and

- *Alteplase 2nd Syringe (Paed Stroke)*



Step 4: Create Order for Syringe 1



Step 5: Create Order for Syringe 2

Reconstitution/Dilution

Reconstitution Concentration 1mg/mL

- Each 10mg vial of IV Alteplase (tPA) is to re-constituted with either supplied diluent or 10ml of Water for Injection
- Each 50mg vial of IV Alteplase (tPA) is to re-constituted with either supplied diluent or 50ml of Water for Injection

Do not shake, use gentle inversion only

Weight	Vials to use	Where stored
10 to 33 kg	10 mg vials	PICU Drug-room Hillside
> 33 kg to 55 kg	50 mg vials	PICU Drug-room Riverside
> 55 kg	50 mg and 10 mg vials (**maximum dose 90mg**)	50mg stored in PICU Drug-room Riverside 10mg stored in PICU Drug-room Hillside

Route and Method of Administration

- IV Alteplase (tPA) should be administered intravenously as NEAT (undiluted) infusion

Total Dose 0.9mg/kg (maximum 90mg) – prepare 2 syringes:

- **Syringe 1 – given as a push over 1 minute** - 0.09mg/kg (10% of total dose) –THEN
- **Syringe 2 – given as an infusion over 59 minutes** - 0.81mg/kg (90% of total dose) (max 81mg)
    - IV Alteplase (tPA) must be infused using dose error reduction software (DERS) using the DERS – "Dose over Time" option in Alteplase profile in the B Braun syringe driver

Compatibility

- IV Alteplase (tPA) is compatible with sodium chloride 0.9% ONLY
- IV Alteplase (tPA) is incompatible with heparin

Contraindications/Precautions

See Appendix 4 – Contraindications for Thrombolysis with IV Alteplase – 2 pages.

Clinical Considerations

Nursing Ratios and Target Parameters During and Post IV Alteplase (tPA) Infusion

- The patient must be nursed 1:1 for at least the first two hours
- Patient should initially be nil by mouth until it is deemed that feeding is safe by the treating medical team.
- Targets should be consistent with the above chapter regarding neuroprotective care (insert hyperlink)

High Frequency Observations, Monitoring and Documentation During and Post IV Alteplase (tPA) Infusion

During the IV Alteplase (tPA) infusion monitor and document the following in the patient's medical record (ieMR or Clinical Information System):

ALERT

Continuous monitoring needs to occur for seizures.

Seizures are to be communicated to the PICU senior medical team immediately.

- Record IV Alteplase (tPA) infusion:
  - Hourly rate
  - Total volume of infusion delivered
  - Volume infused at the completion of a syringe
- Vital Signs – full monitoring to be attached to the patient – ECG, RR, SaO2 and NIBP
  - HR, RR and BP
    - q15min for 2 hours then,
    - q30min for 6 hours then,
    - q1hr for 16 hours then,
    - q2hr for 24 hours then,
    - q4hr for 24 hours
- Neurological Observations and Vital Signs
  - Pupil size and reaction
  - Extraocular movements
  - GCS
  - Fontanelle (for patients <12 months)
  - Motor response
  - Facial symmetry
  - Signs of increased ICP
    - q15min for 2 hours then,
    - q30min for 6 hours then,
    - q1hr for 16 hours then,
    - q2hr for 24 hours then,
    - q4hr for 24 hours

Signs of Increased ICP

- Headache
- Nausea
- Vomiting
- Increased Blood Pressure
- Widened pulse pressure (the difference between the systolic and diastolic blood pressure)
- Confusion/Decreased level of consciousness
- Dilated or unreactive pupils
- Double vision, loss of vision or abnormal eye movements
- Bulging fontanelle (in infants <12 months)

ALERT

Any deterioration in vital signs or neurological observations during or after the infusion are to be communicated to the PICU senior medical team immediately.

If significant neurological deterioration occurs the PICU specialist (SMO) and neurologist should discuss:

- **Resuscitation as appropriate**
- **Stopping the infusion if it is still running**
- **Arranging an urgent CT or MRI**
- **Notifying the Neurosurgical team, Anaesthetist and OT team**

- Strict Fluid Balance
  - q6hr for 72hrs then,
  - q12hr till advised to cease by medical staff
- Review of punctured sites and wounds for any obvious bleeding
  - q1hr for 24 hours
  - If any signs of bleeding or bruising occur, apply pressure and seek urgent medical review
- Assessment for urinary and faecal bleeding
  - All urine should be ward tested to assess for bleeding for q72hrs post administration of IV Alteplase, in the event of frank bleeding seek urgent medical review.
  - All faeces samples should be tested for faecal occult blood for q72hrs post administration of IV Alteplase, in the event of frank bleeding seek urgent medical review.
- Limb circulation observations
  - q1hr for 24 hours
  - If any compromise to limb circulation is identified or suspected, then seek urgent medical review. Refer to neurovascular observations chart in Metavision or ieMR

Mobility Post Administration of IV Alteplase (tPA)

- Mobilisation should be carefully initiated after IV Alteplase (tPA) infusion, as the patient is at risk of bleeding with falls or trauma. The patient should rest in bed for 12-24 hours post completion of the IV Alteplase (tPA) infusion (a commode for toileting can be considered if appropriate assistance to prevent falls can be provided).

Cautions about Anticoagulant and Antiplatelet Agents

- There should not be any administration of any anticoagulant or antiplatelet agents until 24 hours after IV Alteplase (tPA) infusion i.e. VKA/warfarin, LMWH, DOACs (direct oral anticoagulant), unfractionated heparin or antiplatelet agents (other than aspirin).

Investigations post administration of IV Alteplase (tPA)

- Coagulation profile and FBC at completion of infusion and repeat at 4hr then every 6hr for 24hrs.
- CT head (or MRI with SWI) at 24-36hrs to rule out intracranial haemorrhage or sooner if any neurological deterioration.

Low stimulation environment

- Patients with acute stroke are to be nursed in a low stimulation environment for the first 72 hours. This includes but is not limited to a single room (if clinically appropriate), grouping cares, limiting visitors/noise and maximising rest periods between observations.
- At 72 hours, medical and nursing review should determine if continuation of a low stimulation environment is required.

APPENDIX 5A: GAINING CONSENT FOR IV ALTEPLASE (TPA) FOR PAEDIATRIC ACUTE ARTERIAL ISCHAEMIC STROKE

Consent should always be gained from the child's legal guardian prior to the administration of IV Alteplase (tPA) for Paediatric Acute AIS[3]. A standard hospital consent form is available at this link: Consent Child/Young Person (under 18 years)

The treating neurologist is responsible for the verbal discussion of consent with guardians of children where IV Alteplase (tPA) is being considered for treatment of Paediatric Acute AIS. If the neurologist is off site or the patient is in a hospital other than QCH, a phone/videolink consent can be performed with appropriate documentation in the ieMR. It is highly desirable that delayed written consent be performed in these instances with documentation of the discussion of risks and benefits.

Guardian Unavailable for Consent: As a time-critical emergency, consideration of thrombolysis should not be delayed if the legal guardian is unavailable for consent. Clinicians should follow local health department policies regarding consent for emergency treatment in patients who are unable to consent for themselves.

Non-Consent to Blood Transfusion: In situations where there is guardian non-consent to blood transfusion, this needs to be specifically discussed. Thrombolysis with IV Alteplase should not be in any way refused to children whose guardian does not give consent to transfusion. However, the guardian needs to be aware that their decision to refuse consent may be over-ridden in situations where the child's life is at risk or there is risk that the child may suffer serious or permanent damage.[4]

ALERT

Administration of IV Alteplase (tPA)

The absence of high-quality evidence means that benefit over harm for these children cannot be accurately assessed. Where administration of IV Alteplase (tPA) is being considered for children with acute AIS, an experienced team of paediatric neurologists, paediatric radiologists, paediatric haematologists, and if required interventional neuroradiologist and paediatric critical care specialists within a Tertiary Paediatric Hospital should be involved. Professionals should take a cautious approach, appreciating that the safety and efficacy in children remains to be elucidated.

APPENDIX 6B: INFORMATION FOR PARENTS AND GUARDIANS - IV ALTEPLASE (TPA) USE IN PAEDIATRIC ACUTE ARTERIAL ISCHAEMIC STROKE

This is a guide only as information provided may be modified for individual case factors as determined by the medical expertise of the neurologist.

Refer to Parent Information Handout (in development as at September 2019).

What is Acute Arterial Ischaemic Stroke?

Acute arterial ischaemic stroke is a sudden loss of brain function caused by a blood clot in an artery or blood vessel of the brain. Symptoms may include sudden onset of a severe headache without a known cause, sudden weakness or numbness of the face, arm or leg, usually on one side of the body; difficulty walking, seeing, or speaking; and confusion and trouble understanding speech. This blockage in the brain prevents brain cells from getting the oxygen-carrying blood they need to function and causes these cells to start dying. Brain cell death can result in permanent disabilities.

What is IV Alteplase (tPA) used for?

IV Alteplase (also known as tissue plasminogen activator (tPA), can be used to treat patients with acute ischaemic stroke. Patients can only receive IV Alteplase if they begin treatment within 4 ½ hours after their stroke symptoms start and only after they have had a scan to rule out bleeding in the brain. IV Alteplase is registered by the Therapeutic Goods Administration in Australia for use in adults who have stroke, but it is not registered for the use in children. Therefore, its use in children is experimental.

How does IV Alteplase (tPA) work?

IV Alteplase works by helping to dissolve the clot that is blocking the blood vessel in your child's brain and causing the stroke.

What are the Potential Benefits of IV Alteplase (tPA)?

In major adult clinical studies, patients who received IV Alteplase (tPA) were more likely to recover from their strokes with minimal or no disability than patients who did not receive IV Alteplase (tPA). IV Alteplase (tPA) is now used as standard practice in adult hospitals. Because stroke is so rare in children clinical studies of IV Alteplase (tPA) have not been performed, however we hope that children will benefit in the same way as adults.

Before your child receives IV Alteplase (tPA), they need to have some tests and examinations. These tests will include a brain scan (MRI or CT), blood tests, medical examination. These tests and procedures are "standard of care" for acute stroke in childhood. This means that most children's stroke specialists do them on children who have just had a stroke. The results of the following tests will show us if your child is suitable to be given IV Alteplase (tPA). If your child is deemed unsuitable to receive IV Alteplase (tPA), they will continue with the standard treatment for stroke.

What are the Possible Risks, Side-effects or Discomforts of Stroke Treatment?

Medical treatments often cause side effects. Your child may have none, some or all the side effects listed below. Side effects may be mild, moderate or severe.

If your child has any side effects or you are worried, please talk to us. We will be looking out for side effects too. We will discuss the best way of managing any side effects with you.

Many side effects go away shortly after treatment ends. However, sometimes side effects can be serious, long lasting or permanent.

If a severe side effect or reaction occurs, we may need to stop your child's treatment.

Bleeding:

The most important possible side effect of IV Alteplase (tPA) is bleeding, which in rare cases can be life-threatening or cause permanent injury.

- **Your child could have bleeding in his or her brain, especially in the area of their stroke.** About 2.5% of adults (2.5 in 100) have serious bleeding in their brain after receiving IV Alteplase (tPA) for a stroke.
- **Bleeding in the brain can happen in stroke even if IV Alteplase (tPA) is not given, but we expect that IV Alteplase (tPA) may increase the chance of this occurring**.
- **Bleeding in other parts of the body:** Bleeding can occur anywhere in the body. e.g. in the gut/abdomen, urinary tract (bladder), lungs, around the heart, from the mouth or nose, or around the IV site.
- We will watch your child very carefully for bleeding after they receive the IV Alteplase (tPA). If bleeding occurs, we expect it to happen within the first 2 days. If we are worried that your child has had bleeding in the brain, we will get a CT or MRI scan immediately to check.

Reactions to IV Alteplase (tPA):

- **Allergies:** In adults, approximately 1.6% (1.6 in 100) of people have allergic reactions to IV Alteplase (tPA). Reactions can be mild and include rash and hives. More serious reactions are difficulty breathing, a drop in blood pressure or a fast heart rate.
- **Nausea, Vomiting or Fever:** IV Alteplase (tPA) can cause nausea, vomiting or fever.
- If your child has a reaction to the IV Alteplase (tPA), we will have a senior doctor review your child and give your child medicine(s) to help. In some instances, we may stop giving the medication.

Risks of Brain Scans:

- **Radiation:** As part of everyday living, everyone is exposed to naturally occurring background radiation. In Paediatrics we are very careful regarding radiation associated with brain scans. We will only perform a CT scan if we believe the benefit of getting the test result outweighs the risk.

Risks of Blood Tests

- **Pain:** Children who have blood tests can experience pain. Parents can help by comforting their child during this procedure.

What will Treatment with IV Alteplase (tPA) be like?

IV Alteplase (tPA) will be given intravenously, which means into your child's vein. It will take approximately one hour to give.

During and after the IV Alteplase (tPA) we will closely monitor your child. The monitoring will be explained to you by your treating doctor. It will include observations made by medical and nursing staff, blood tests and brain scans. We will tell you if we are worried about any of these observations or tests. You are always welcome to ask questions.

What if the Treatment with IV Alteplase doesn't work?

Sometimes treatment with IV Alteplase (tPA) does not unblock the artery. Another treatment called thrombectomy or clot retreival may be discussed with you if your child is eligible based on the results of their scans.

Are there any other options to IV Alteplase (tPA) for my child?

If you do not wish for your child to receive IV Alteplase (tPA), we will provide standard treatment for acute stroke. We will still perform observations and tests and do everything we can to protect the parts of their brain that have not had a stroke.
Instead of IV Alteplase, your child may be started on a heparin infusion. Heparin is a medication used to thin the blood. It does not dissolve clots. We use it to try to stop the clots getting any bigger. Some children may be treated with other blood thinning drugs including Aspirin, Warfarin or Enoxaparin. Your child's doctor will talk to you about these treatments.

The Doctors and Nurses are closely monitoring my Child's Blood Pressure. Why?

Some children have temporary high blood pressure in response to a stroke. The increase in blood pressure may help by getting more blood to the brain. However, if blood pressure is too high it may increase the risk of bleeding. Since no one knows the best blood pressure level to aim for, we will carefully balance the possible risk and benefits. We will monitor blood pressure very closely and provide your child with the best standard of care for children who have had a stroke.

APPENDIX 6: PROTOCOL FOR ENDOVASCULAR THROMBECTOMY

Recommendation for Use of Endovascular Thrombectomy in Paediatric Acute Arterial Ischaemic Stroke

For patients with ischaemic stroke caused by a large vessel occlusion in the internal carotid artery, proximal middle cerebral artery (M1 segment, bifurcation or proximal M2), basilar artery or with tandem occlusion of both the cervical carotid and intracranial large arteries, endovascular thrombectomy should be considered when the procedure can be commenced up to 24 hours after they were last known to be well if clinical and MR or CT perfusion or MRI features indicate the presence of salvageable brain tissue.

Eligible stroke patients should receive intravenous thrombolysis while concurrently arranging endovascular thrombectomy, with neither treatment delaying the other.

Eligibility Criteria for Case Discussion between QCH Neurologist and Interventional Neuroradiologist:

The patient must meet all of the following criteria (these are only criteria for paediatric neurologist at QCH phoning interventional neuroradiology):

1. Stroke symptom onset < 24 hours prior to feasibly commencing endovascular thrombectomy (excluding basilar artery occlusion where thrombectomy may be considered >24 hours post stroke onset)
2. Age ≥ 2 years (special consideration might apply in infants and children <2yr with cardiac disease)
3. Occlusion of the internal carotid artery, proximal segment of the middle cerebral artery (M1, bifurcation or proximal M2), the basilar artery or with tandem occlusion of both the cervical carotid and intracranial large arteries.
4. No previously known or current suspicion of vasculitis, or Moyamoya disease (focal cerebral arteriopathy is NOT an absolute contraindication)
5. Persistent disabling neurological deficit (PedNIHSS ≥4; note obtaining the pedNIHSS score should not delay discussion with interventional neuroradiology)

All initial phone calls to the Interventional Neuroradiologist are to be made by the QCH Consultant Neurologist on-call and preferably with the Consultant Radiologist in attendance.

Imaging

All neuroimaging must be immediately electronically transferred to RBWH PACS in a time critical fashion (sequence by sequence if possible).

The interventional neuroradiologist may request further neuroimaging.

For patients where the stroke onset is >6 and <24hrs prior to commencement of endovascular thrombectomy, the presence of salvageable brain tissue must be demonstrated by MR or CT imaging.

Anaesthetics

If the patient is anaesthetised for the initial neuroimaging then the anaesthetist will discuss ongoing need for anaesthetic with the Radiologist and Neurologist prior to proceeding with extubation. There may be ongoing need for anaesthetics for emergent endovascular thrombectomy. These decisions need to occur prior to extubation and stand down of the anaesthetic and ORS teams. If there is delay to OT consideration should be given to interim PICU transfer.

Phone Calls made by Neurologist to Activate an Endovascular Thrombectomy

If a decision is made to proceed with endovascular thrombectomy:

- The Neurologist will:
  - Notify the Paediatric Intensivist via switch
  - Notify the Consultant Neurosurgeon via switch
  - Ensure the Interventional Neuroradiologist has the guardian's contact details for consent purposes
  - **Delegate a present treating medical officer (ED/PICU) to**
    - Notify the Anaesthetic Team
      - Duty Anaesthetist – via switch
      - Anaesthetic TL - extension 1374 or 1376 (0800-2400) ***
    - Fill in the Anaesthetic Booking Form
- The PICU team (Registrar or Consultant) will liaise with anaesthetics and radiology

***** The nurse manager will be responsible for calling in the ORS team out of hours (2400-0800, every day).**

Phone Calls made by Radiologist to Activate an Endovascular Thrombectomy

The Radiologist (in conjunction with the interventional neuroradiologist) will follow the radiology departmental internal procedure for endovascular thrombectomy including staff call in processes.

Consent for Endovascular Thrombectomy

Consent for endovascular thrombectomy will be obtained by the Interventional Neuroradiologist in conjunction with the QCH Paediatric Neurologist. The contact details for the consenting parent/carer are to be provided to the Interventional Neuroradiologist at the time of referral.

The interventional neuroradiologist must also hold a discussion with the patient/ carer/ guardian prior to the procedure. The discussion must be documented in the ieMR. This can occur retrospectively if the family discussion occurs by phone/videolink. The following points must be discussed with the family and documented in ieMR:

- The criteria that the patient has met making them eligible for endovascular thrombectomy
- Potential risks of endovascular thrombectomy (specific procedural risks will be discussed with the family by the Interventional Neuroradiologist)
- The limited safety and efficacy data for endovascular thrombectomy in paediatric patients

Training, Credentialing and Paediatric Experience for Paediatric Endovascular Thrombectomy

Endovascular thrombectomy should only be performed by an experienced interventional neuroradiologist with recognised training in the procedure (Conjoint Committee for Recognition of training in interventional neuroradiology CCINR.org.au) and with sufficient experience in paediatrics. For procedures performed at Queensland Children's Hospital, the interventional neuroradiologist must be credentialed to perform this procedure. If the on-call interventional neuroradiologist is not credentialed to provide services at QCH, or is unavailable, they will liaise with other Brisbane interventional neuroradiologists if available to discuss the

patient directly with the referring QCH Paediatric Neurologist. Emergency credentialing can be undertaken in some circumstances.

Clinical Care following endovascular thrombectomy:

- The patient is to be admitted to the paediatric intensive care unit.
- Care should continue as per this guideline.
- Specific post-procedure observations will be requested by the interventional neuroradiologist.
- If the patient has received IV Alteplase (tPA) then the relevant pathway for post-care following IV Alteplase (tPA) should also be followed.
- Non-contrast CT should be performed to exclude haemorrhage at < 24 hours post procedure. MRI including DWI and TOF MRA (plus CE-MRA neck vessels in cases with dissection) is useful within the 48 hours following the procedure to assess efficacy and to prognosticate.
- Anti-thrombotics will be decided at the time of the procedure on a case-by-case basis through discussion between the interventional neuroradiologist and QCH Paediatric Neurologist. This is usually withheld until after the post procedural CT and is also dependent on IV alteplase use.

APPENDIX 7: BLOOD PRESSURE MEASUREMENTS FOR INFANTS AND CHILDREN

SBP/DBP (mmHg)				
Age	Boys		Girls	
	50th*	95th*	50th*	95th*
1	80-89/34-37	98-106/54-58	83-90/38-42	100-107/56-60
2	84-92/39-44	101-110/59-63	85-91/43-47	102-109/61-65
3	86-95/44-48	104-113/63-67	86-93/47-51	104-110/65-69
4	88-97/47-52	106-115/66-71	88-94/50-54	105-112/68-72
5	90-98/50-55	108-116/69-74	89-94/52-56	107-113/70-74
6	91-100/53-57	109-117/72-76	91-98/54-58	108-115/72-76
7	92-101/55-59	110-119/74-78	93-99/55-59	110-116/73-77
8	94-102/56-61	111-120/75-80	95-101/57-60	112-118/75-78
9	95-104/57-62	113-121/76-81	96-103/58-61	114-120/76-79
10	97-106/58-63	115-123/77-82	98-105/59-62	116-122/77-80
11	99-107/59-63	117-125/78-82	100-107/60-63	118-124/78-81
12	101-110/59-64	119-127/78-83	102-109/61-64	119-126/79-82
13	104-112/60-64	121-130/79-83	104-110/62-65	121-128/80-83
14	106-115/60-65	124-132/80-84	106/112-63-66	123-129/81-84
15	109-117/61-66	126-135/81-85	107-113/64-67	124-131/82-85
16	111-120/63-67	129-137/82-87	108-114/64-68	125-132/82-86
17	114-122/65-70	131-140/80-89	108-115/64-68	125-132/82-86
1-3 months	65-85/35-55		65-85/35-55	
3-6 months	70-90/33-65		70-90/33-65	
6-12 months	80-100/40-65		80-100/40-65	

Reference: Australian Childhood Stroke Advisory Committee. Guideline for the diagnosis and acute management of childhood stroke – 2017.

APPENDIX 8: CRITERIA FOR DISCHARGE FROM PICU TO THE WARD

- Alteplase infusion completed plus 12 hours post-Alteplase observation
- Post-Alteplase neuro-imaging has been completed and reviewed by PICU Consultant and Neurologist – outcome of review documented
- Self-ventilating
- Haemodynamic stability, including nil inotropic support for previous 6 hours
- GCS ≥ 12 for 4 hours or GCS stable for 48 hours
- Referral to Allied Health team is desirable but not compulsory
- Referral to Rehabilitation team is desirable but not compulsory
- Coagulation Profile completed and reviewed within 12 hours prior to discharge (if within 24 hours of IV Alteplase (tPA) administration)
- One patent IV cannula
- Arterial line removed
- NGT feeds and/or maintenance fluids ordered if required
- Provide instructions for Post-Alteplase observations

APPENDIX 9: ACUTE WARD NURSING MANAGEMENT

All patients who have had an acute stroke (whether administration of IV Alteplase has occurred or not) should have a low stimulation environment for the first 72hrs. This includes but is not limited to a single room (if clinically appropriate), grouping cares, limiting visitors/noise and maximising rest periods between observations. At 72hrs medical and nursing review should establish if this needs to be continued

- iEMR: Admit to Inpatient and follow all usual iEMR processes
- For the first 72hrs post stroke identify patient as a "patient of concern" for medical and safety nurse review
- Weight on admission and then weekly on Tuesdays – document in iEMR
- Medications and IV Fluids therapies as ordered in MAR
- Admission Issues related specifically to Acute Stroke

  - High Frequency Observations post IV Alteplase - ongoing at PICU to ward handover
    - If a patient has received IV Alteplase the high frequency observation requirements set out in Appendix 5 should be strictly followed – PICU should advise where in this regime the patient is at handover
  - High Frequency Observations post IV Alteplase - complete at PICU to ward handover
    - If the IV Alteplase high frequency observation requirements are complete or the patient did not receive IV Alteplase, the patient should have q4hr neurological and vital signs observations for 24hrs then q6hr observations until transfer to the rehabilitation ward unless more frequent observations are directed by medical staff.

ALERT - Deterioration in GCS or seizures

Immediately advise senior medical team of any deterioration in GCS or occurrence of seizures.

The On-Call Neurologist must also be advised as this may represent recurrent stroke, stroke extension or serious stroke complication.

  - CEWT: Follow CEWT parameter processes for review and escalation as indicated
  - Temperature: In the first 3 days after an acute stroke, temperature readings above 37.5 degrees should be treated with Paracetamol as a neuroprotective measure unless otherwise advised by medical staff. General medical review should occur if temperature persists.
  - Bed position: medical advice should be sought about whether a specific head elevation of the bed is recommended
  - Pressure Area Care: Attention to pressure area care for patients with paresis and/or sensory deficits.

- Seizures:
    - Observe closely for signs of seizure activity
    - MET call for any seizure activity greater than 5 minutes or as otherwise needed
    - Urgent medical review for any seizure activity if MET not activated
    - All seizures need to be notified to the On-Call Neurologist after medical review – seizures following acute stroke may indicate stroke recurrence, stroke extension or serious stroke complication
- Nutrition: Acute stroke patients should remain NBM with nutrition administered via the NGT or IV routes until a swallow assessment is completed.
- Fluid Balance: All acute stroke patients (irrespective of IV Alteplase administration) should have strict fluid balance q6hly for the first 72 hours and q12hrly thereafter until advised to cease by medical team
- Bowel motion monitoring: q12hrly records of bowel motions (BO, BNO) should occur throughout the admission for acute stroke.
- Consultations required during acute ward admission:
    - Speech and Language Therapy
    - Occupational Therapy
    - Physiotherapy
    - Dietetics
    - Social Work
    - Rehabilitation Team
    - Neurosciences Nursing Team (Patient/Carer Education re stroke)

APPENDIX 10: CRITERIA LED DISCHARGE FROM ACUTE TO REHABILITATION WARDS

- Primary reason for hospitalisation is now for rehabilitation.
- All investigations are completed.
- All treatments are focused towards rehabilitation.
- All infusions ceased.
- Initial therapy assessments completed.
- No interventions in response to observations for 48 hours

  e.g. No fluid boluses, no infective causes found in relation to fevers (paracetamol acceptable).
- No evidence of infection.
- No seizures for 24 hours.
- NGT / oral Feeding established as appropriate.
- IV cannulas removed.
- Duration of Clexane / Warfarin / Aspirin – established and documented by Medical Team/s.